REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
22-09-2003	Technical Viewgraph Presentation	

4. TITLE AND SUBTITLE

Investigating the Strain Rate Effects on Cumulative Damage in a Highly Filled Polymeric Material

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER
2302

5e. TASK NUMBER
0378

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

AFRL-PR-ED-VG-2003-238

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)
AFRL-PR-ED-VG-2003-238

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

For presentation at the International Conference on Mechanics of Time-Dependent Materials taking place in Lake Placid, NY, from 7-10 October 2003.

14. ABSTRACT

20031017 121

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Leilani Richardson
a. REPORT	b. ABSTRACT	c. THIS PAGE	A	14	19b. TELEPHONE NUMBER *(include area code)*
Unclassified	**Unclassified**	**Unclassified**			(661) 275-5015

Investigating the Strain Rate Effects on Cumulative Damage in a Highly Filled Polymeric Material

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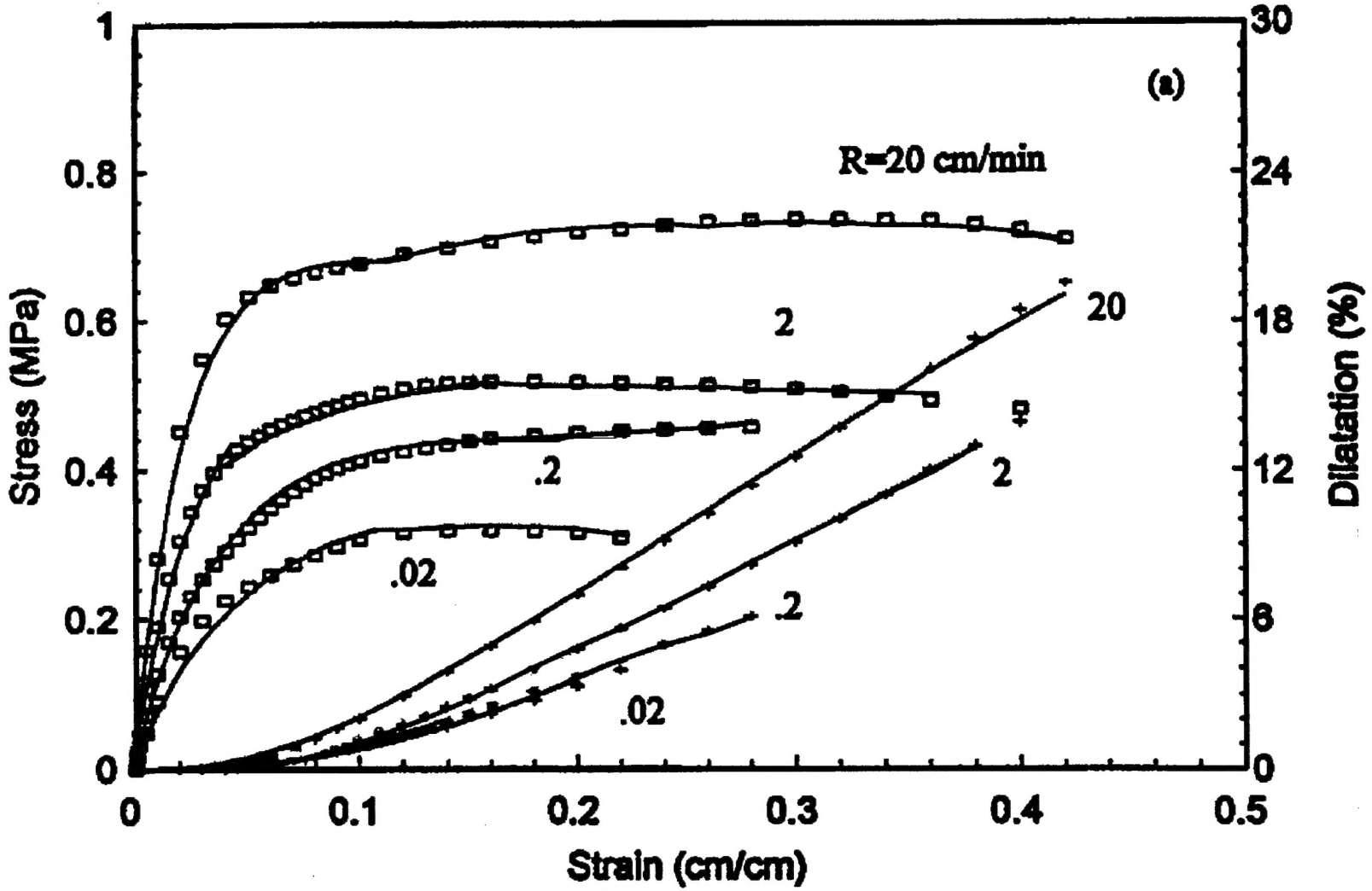
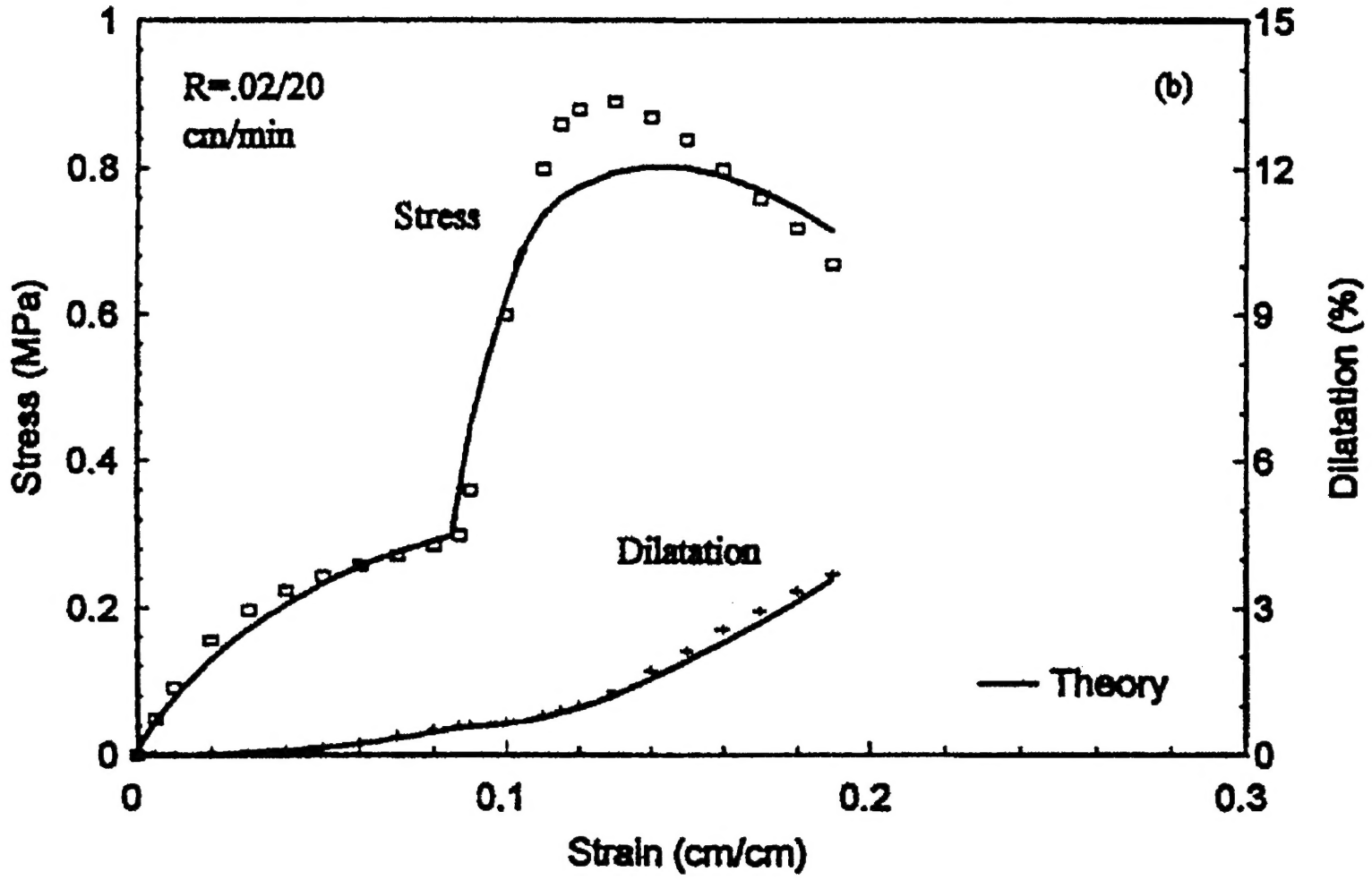
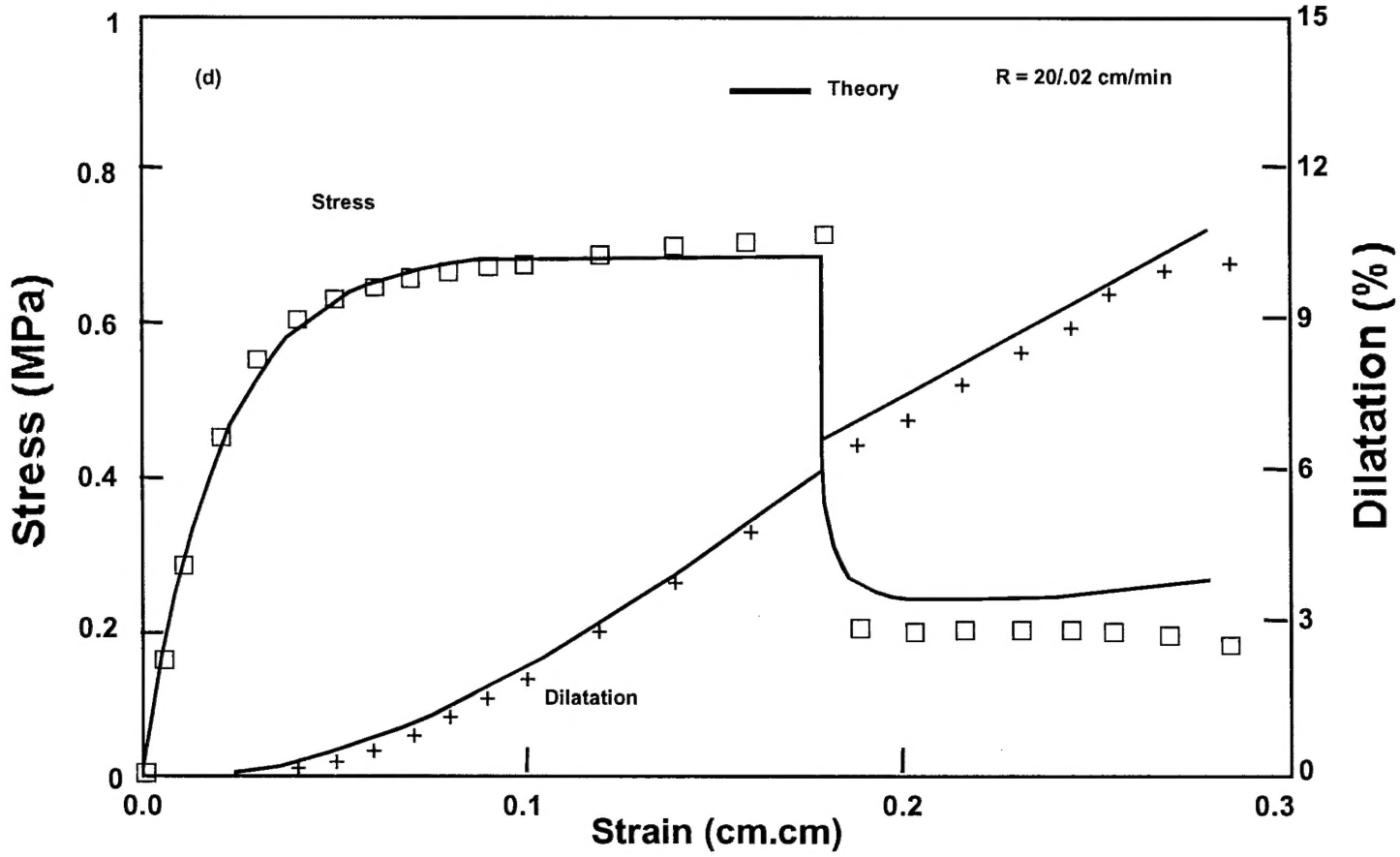
Objective:

- **Investigate Cumulative Damage in a Highly Filled Polymeric Material under Constant and Dual-Displacement Rate Loading Conditions.**
  - **Constant Displacement Rates: 0.02, 0.2, 2, 20 cm/min**
  - **Dual-Displacement Rate:**
    - **0.02 cm/min – 20 cm/min**
    - **0.2 cm/min – 20 cm/min**
    - **20 cm/min – 0.02 cm/min**


(a)
R=20 cm/min
2
.2
.02
20
2
.2
.02
Stress (MPa)
Dilatation (%)
Strain (cm/cm)
0
0.2
0.4
0.6
0.8
1
0
6
12
18
24
30
0
0.1
0.2
0.3
0.4
0.5


R=.02/20
cm/min
(b)
Stress
Dilatation
Theory
Stress (MPa)
Dilatation (%)
Strain (cm/cm)
0
0.2
0.4
0.6
0.8
1
3
6
9
12
15
0.1
0.2
0.3

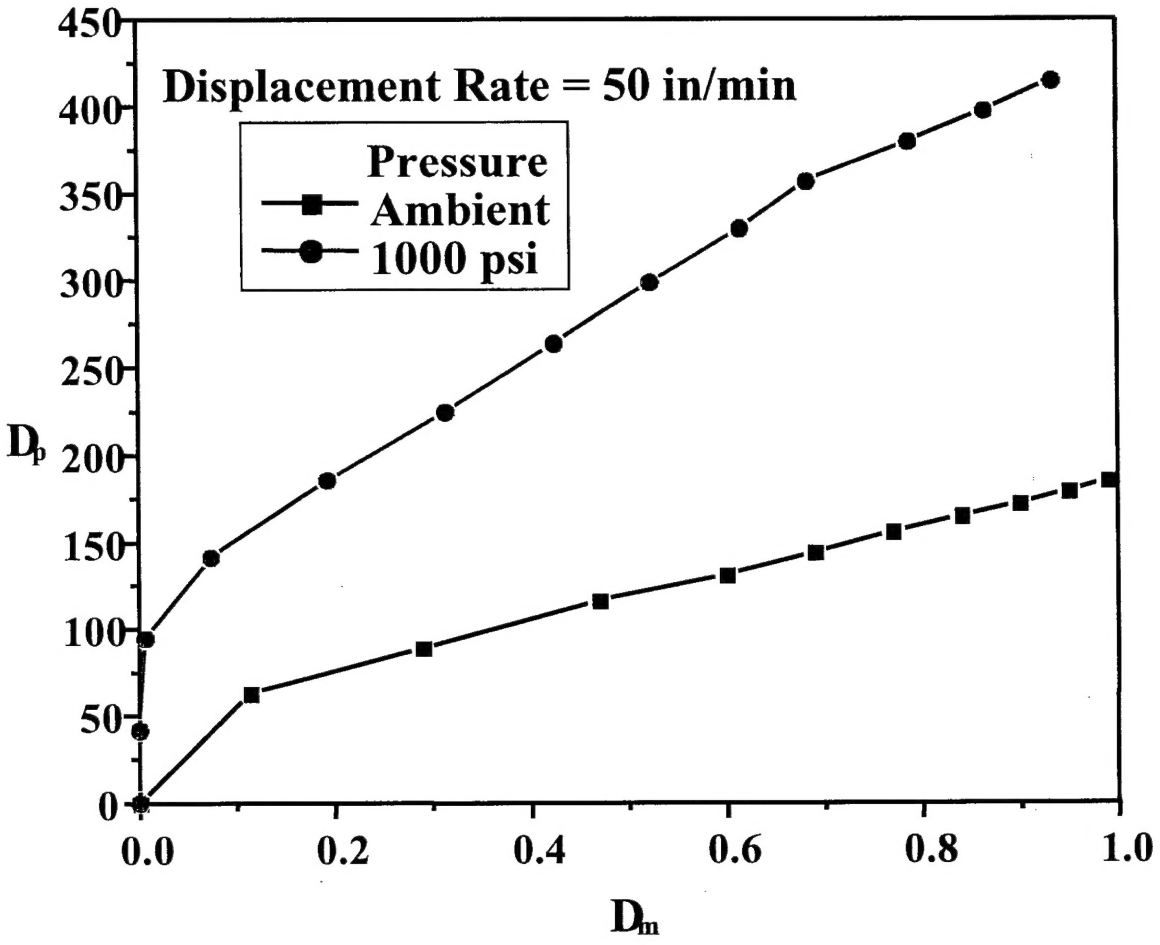

(d)
Theory
R = 20/.02 cm/min
Stress
Dilatation
Stress (MPa)
Dilatation (%)
Strain (cm.cm)
0
0.2
0.4
0.6
0.8
1
0.0
0.1
0.2
0.3
0
3
6
9
12
15

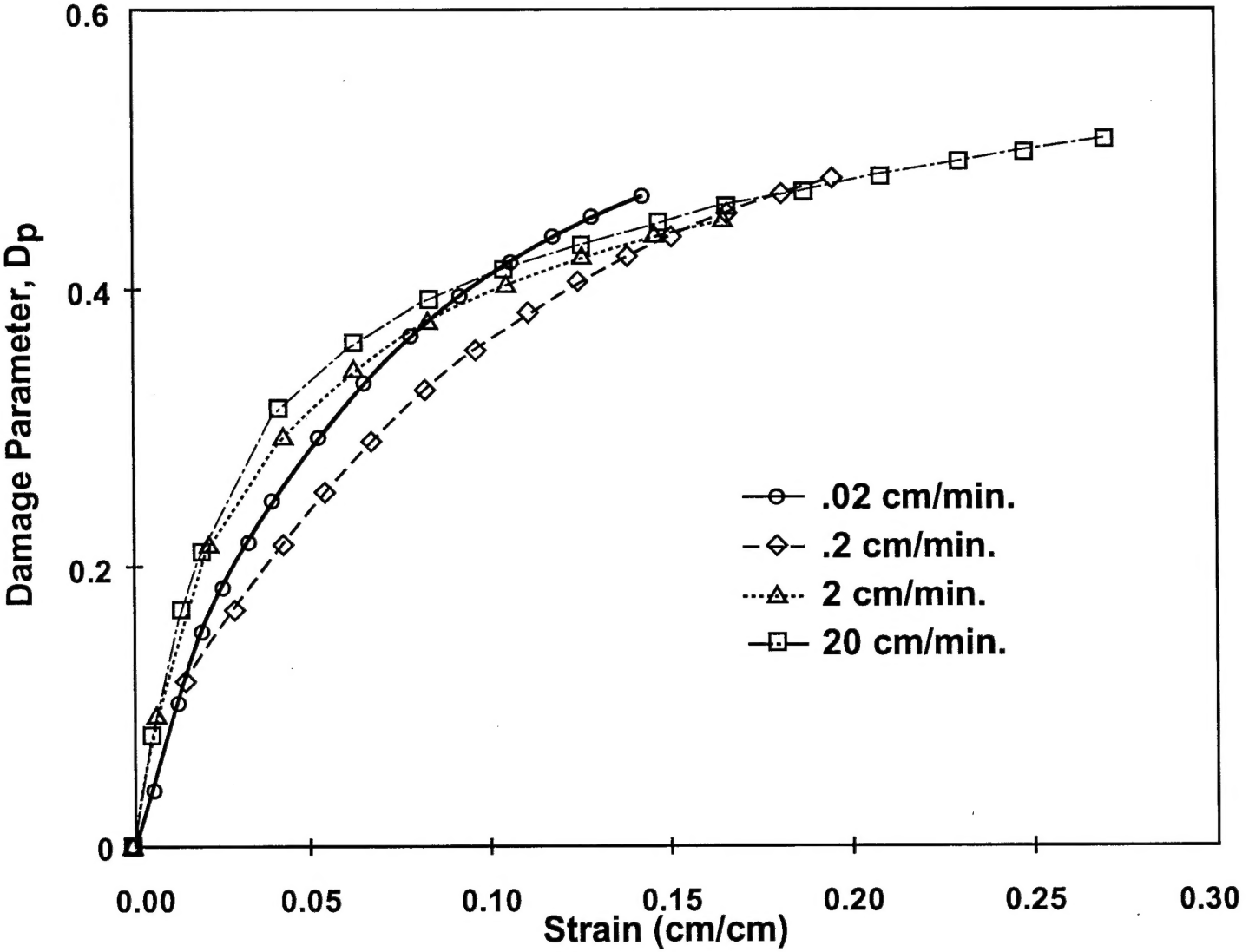
Phenomenological Damage Parameter Dp: $D(t)=\left[\int_0^t \sigma^{\beta}\, dt\right]^{1/\beta}$

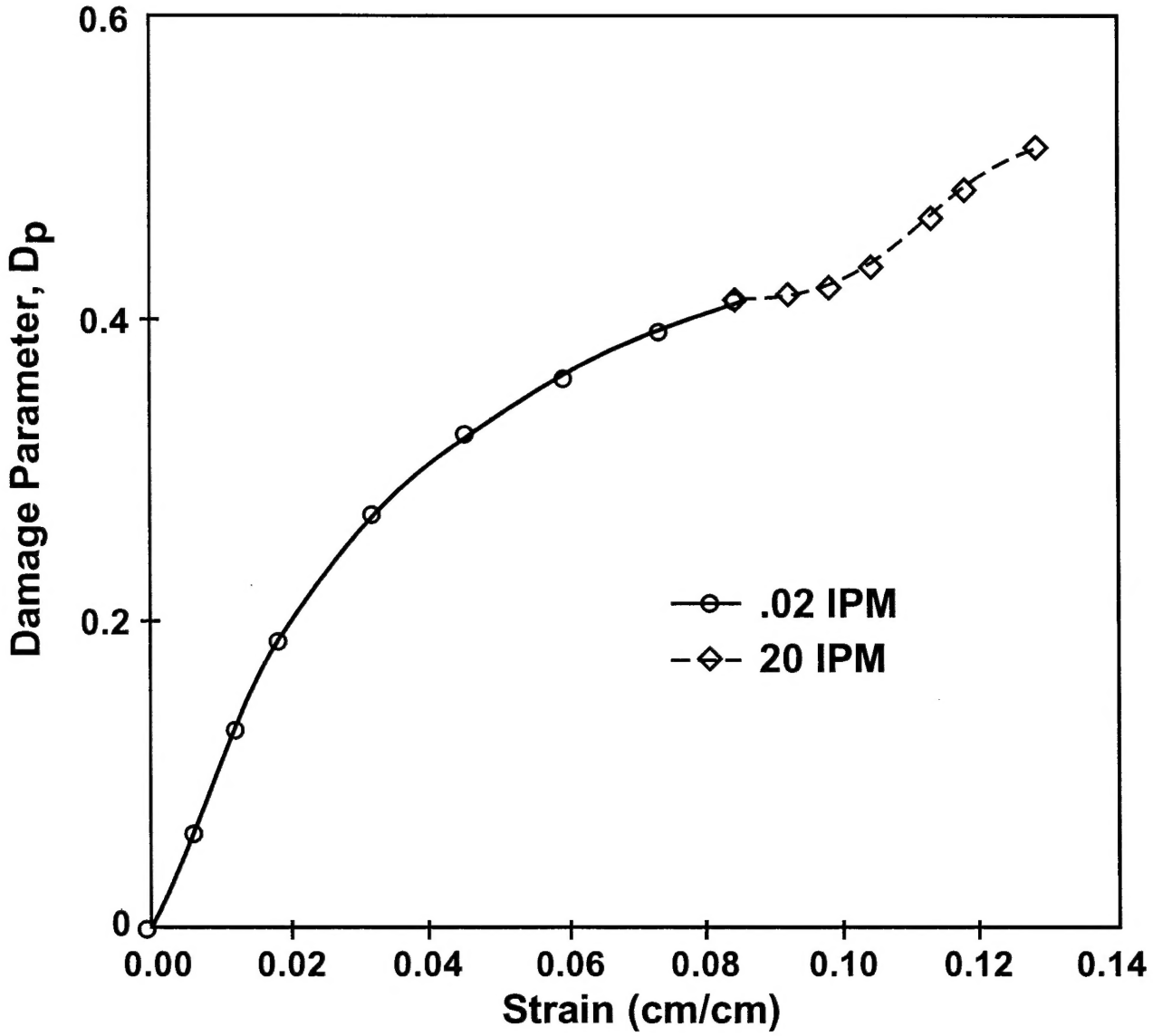
Micromechanics Damage Parameter Dm

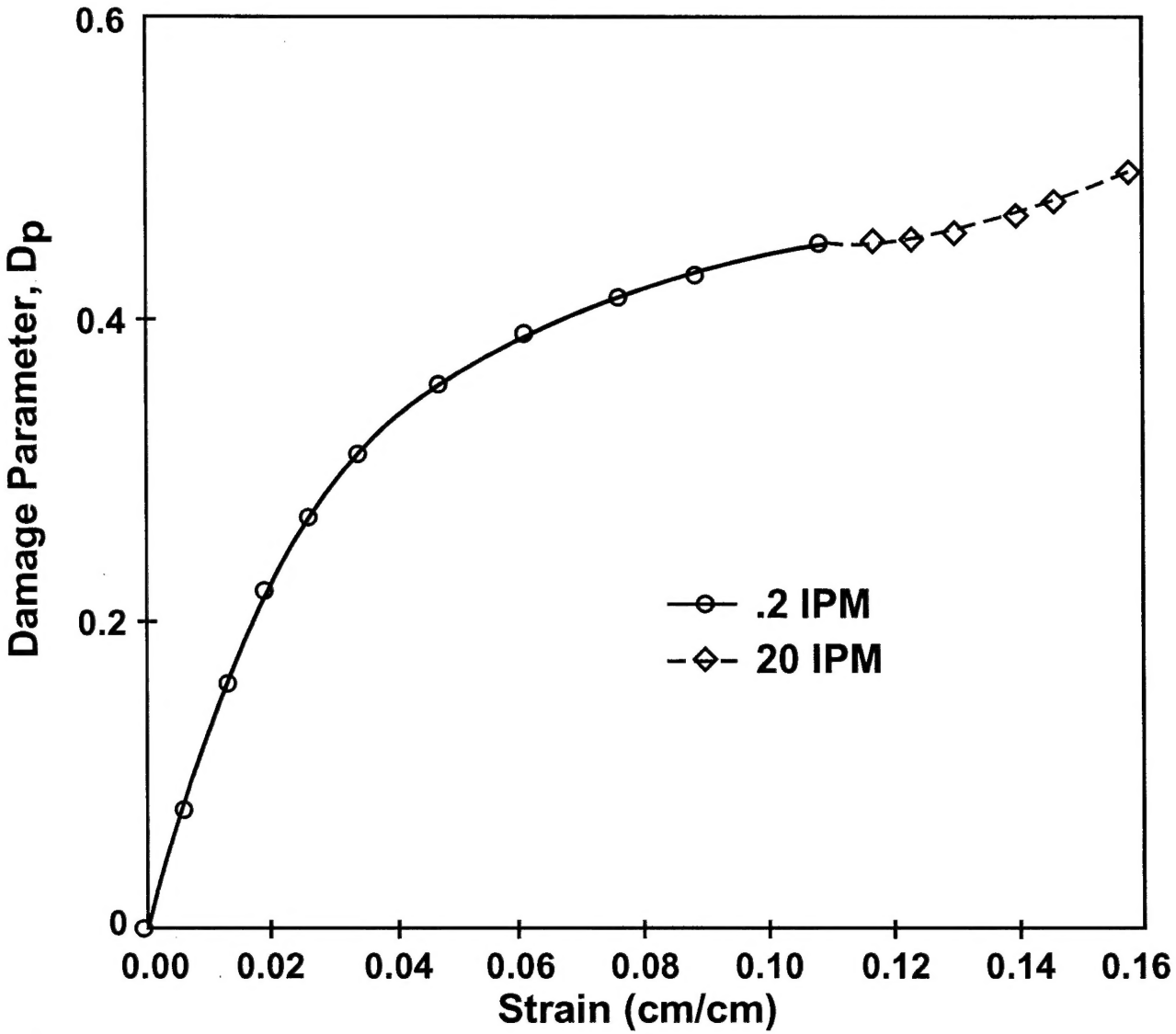
Damage Potential Function: F = f (ε_{ij}) -K

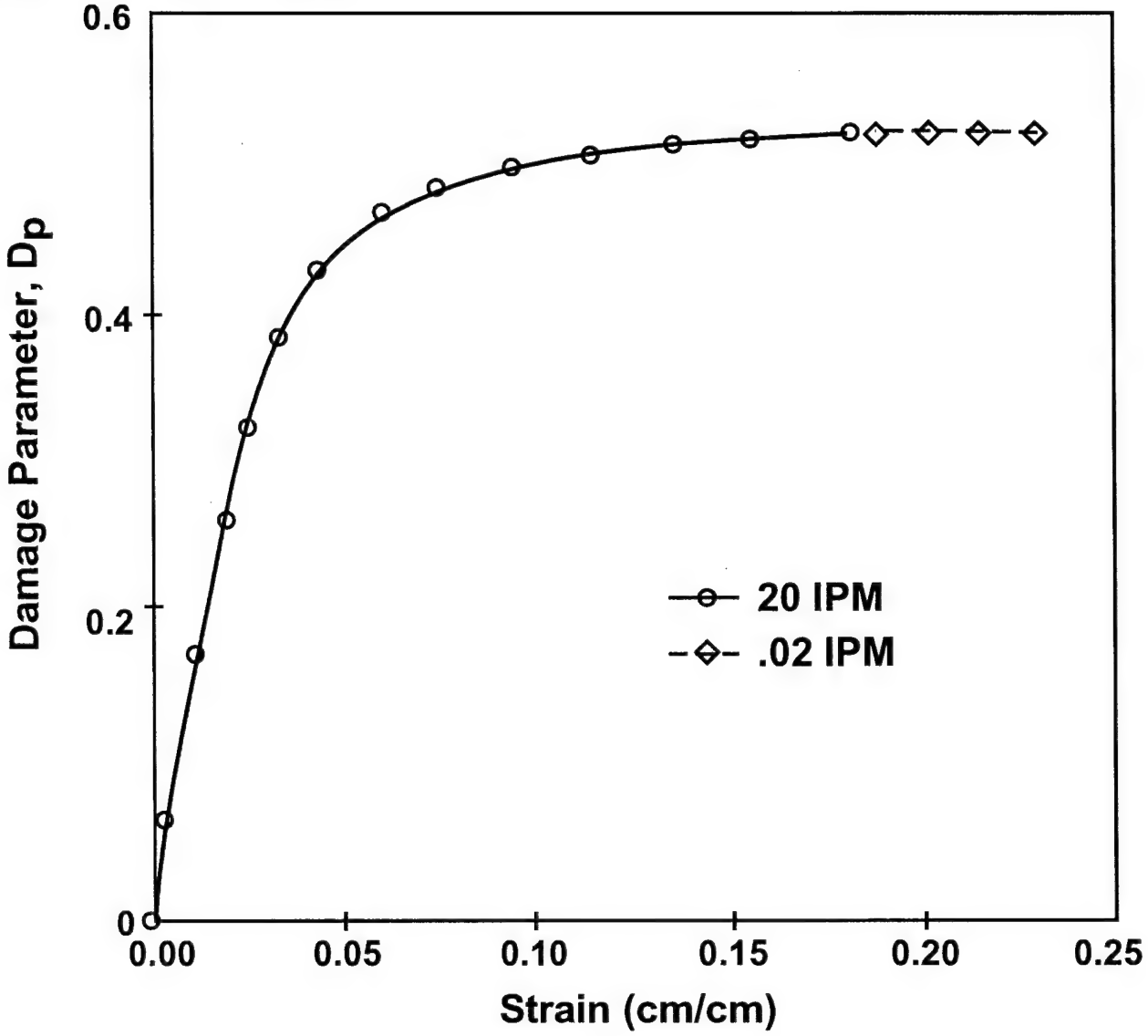
Damage Evolution Law: dDm/dt = [dK/dt] g (ε)

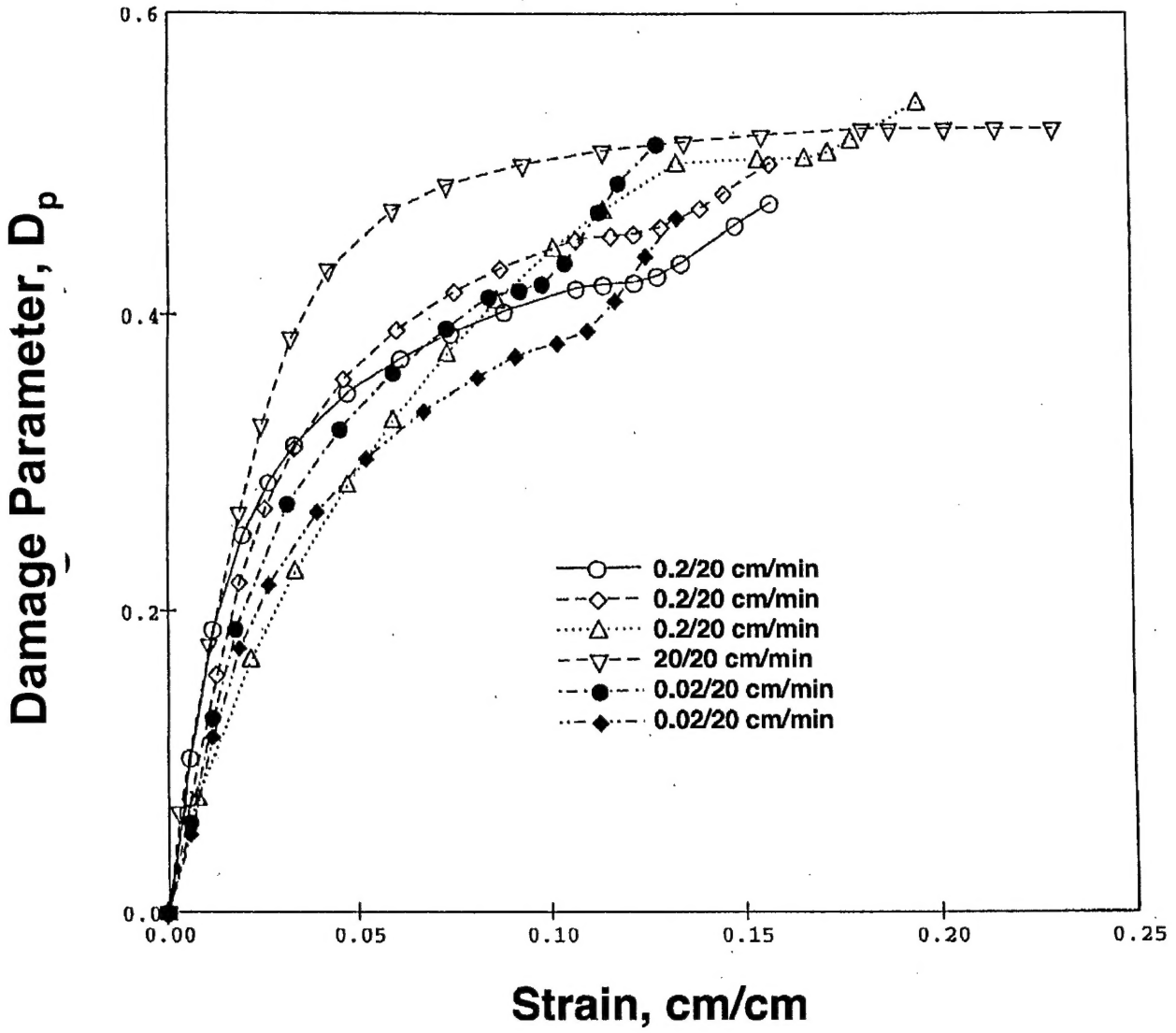


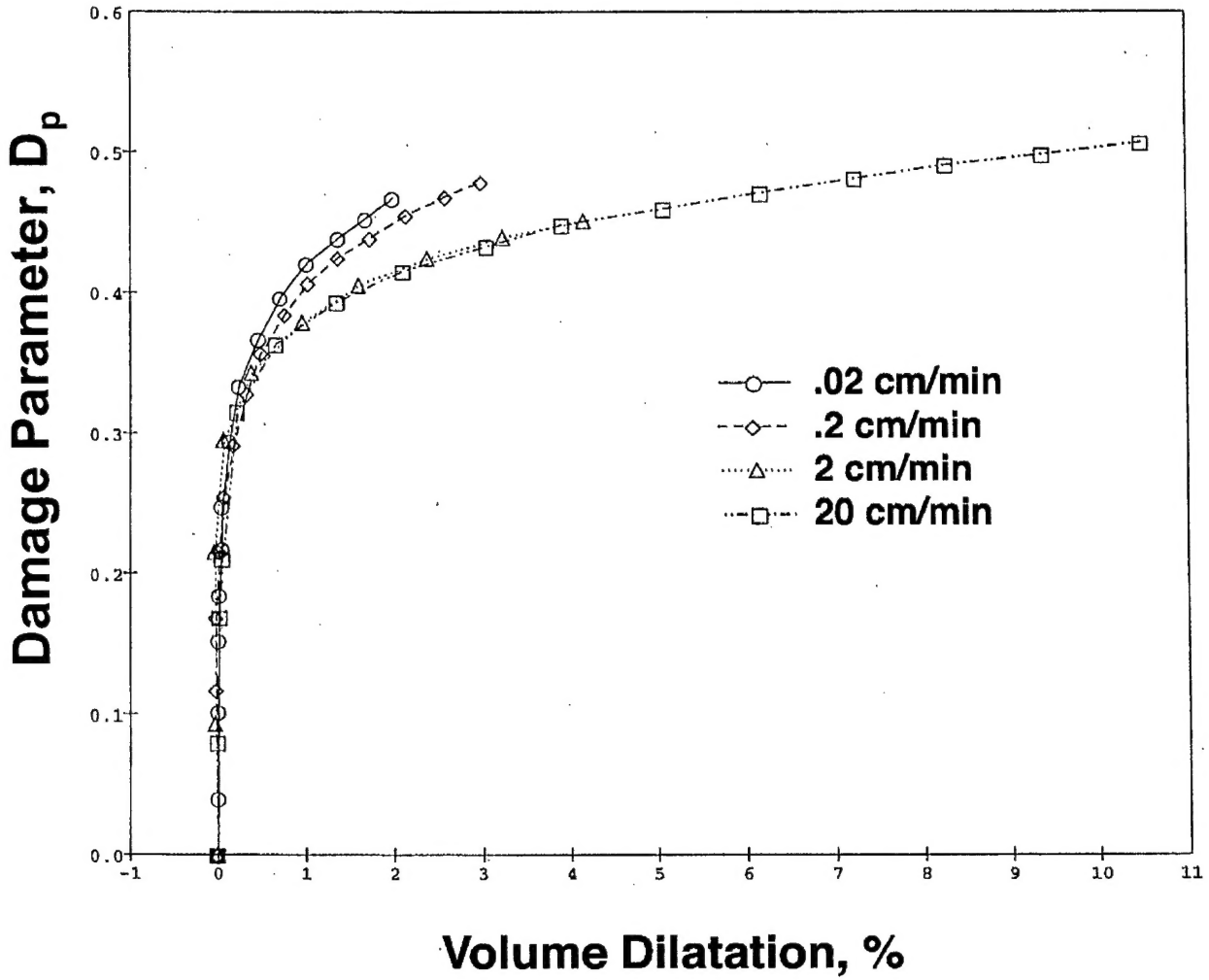

0.6
0.4
0.2
0
Damage Parameter, Dp
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Strain (cm/cm)
.02 cm/min.
.2 cm/min.
2 cm/min.
20 cm/min.

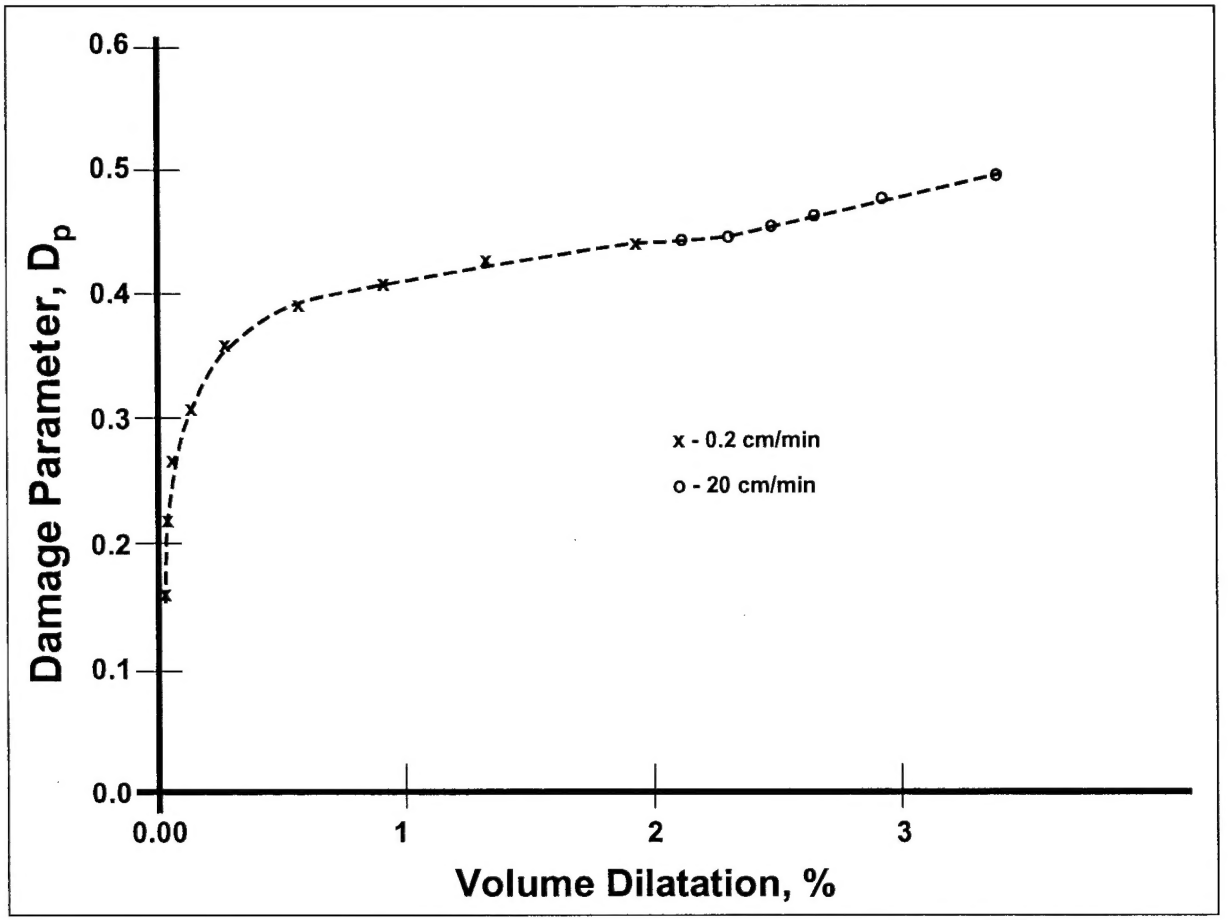

0.6
0.4
0.2
0
Damage Parameter, Dp
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Strain (cm/cm)
.02 IPM
20 IPM


0.6
0.4
0.2
0
Damage Parameter, Dp
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
Strain (cm/cm)
.2 IPM
20 IPM


0.6
0.4
0.2
0
Damage Parameter, Dp
0.00
0.05
0.10
0.15
0.20
0.25
Strain (cm/cm)
20 IPM
.02 IPM


Damage Parameter, D_p
0.6
0.4
0.2
0.0
0.00
0.05
0.10
0.15
0.20
0.25
Strain, cm/cm
0.2/20 cm/min
0.2/20 cm/min
0.2/20 cm/min
20/20 cm/min
0.02/20 cm/min
0.02/20 cm/min


Damage Parameter, D_p
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-1
0
1
2
3
4
5
6
7
8
9
10
11
.02 cm/min
.2 cm/min
2 cm/min
20 cm/min
Volume Dilatation, %


0.6
0.5
0.4
0.3
0.2
0.1
0.0
Damage Parameter, D_p
x - 0.2 cm/min
o - 20 cm/min
0.00
1
2
3
Volume Dilatation, %

Conclusions:

- For a given time, displacement rate has a significant effect on the damage intensity.
- The critical damage intensity is insensitive to the displacement rate and loading history.
- A good correlation exists between damage intensity and volume dilatation.
- The phenomenological damage parameter correlates well with the micromechanics damage parameter